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MECHANICAL-PROPERTY DATA Ti-6Al-4V ALLOY, POWDER METALLURGY PRO--ETC(U)  
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# MECHANICAL-PROPERTY DATA

## Ti-6Al-4V ALLOY

POWDER METALLURGY PRODUCT  
CHIP

Issued by

Air Force Wright Aeronautical Laboratory  
Materials Laboratory  
Wright-Patterson Air Force Base, Ohio

11 May 1981

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## Ti-6Al-4V Alloy (CHIP)

### Material Description

✓ This Ti-6Al-4V alloy, a powder metallurgy product from Dynamet Technology, was received as sixty 5/8" diameter x 5" bars, seven 0.125" x 2" x 12" strips, and nine 3/4" x 3" x 3" blanks.

✓ The chemical composition of this lot is as follows:

<u>Chemical Composition</u>	<u>Percent Weight</u>
Aluminum	5.70
Vanadium	4.22
Carbon	0.024
Hydrogen	0.0013
Nickel	0.0112
Oxygen	0.19
Others	0.043
Titanium	Balance.

### Processing and Heat Treating

The Ti-6Al-4V alloy was received in the "CHIP"ed condition. "CHIP" (Cold Hot Isostatically Pressed) processing means the material was cold isostatically pressed at 60,000 psi (413.7 MPa), vacuum sintered at 2250 F (1505 K) for 3 hours and furnace cooled, and hot isostatically pressed at 15,000 psi (103.4 MPa) at 1650 F (1172 K) to achieve the desired density and mechanical properties.

✓ Results of this evaluation show slightly lower strength values than for the wrought annealed material. The tensile and compression results were slightly lower while the bearing and shear results were slightly higher.

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## Ti-6Al-4V

Condition: CHIP<sup>(a)</sup>

Properties	Temperature, F (K)				
	RT	(RT)	400 (477)	800	(700)
<u>Tension</u>					
TUS, ksi (MPa)	127.4	(878.4)	96.0 (661.9)	76.6	(528.2)
TYS, ksi (MPa)	115.8	(798.4)	83.2 (573.7)	60.4	(416.5)
RA, percent	12.2	(12.2)	16.1 (16.1)	26.7	(26.7)
e, percent in 1 in. (25.4 mm)	6.7	(6.7)	7.0 (7.0)	10.8	(10.8)
E, 10 <sup>3</sup> ksi (GPa)	16.9	(116.5)	15.7 (108.3)	13.6	(93.8)
<u>Compression</u>					
CYS, ksi (MPa)	123.8	(853.6)	83.3 (574.4)	61.0	(420.6)
E <sub>c</sub> , 10 <sup>3</sup> ksi (GPa)	15.9	(109.6)	15.0 (103.4)	13.2	(91.0)
<u>Shear</u>					
SUS, ksi (MPa)	88.8	(612.3)	71.3 (491.5)	55.3	(381.4)
<u>Bearing</u>					
e/D = 1.5					
BUS, ksi (MPa)	212.6	(1465.7)	154.6 (1065.8)	151.1	(1041.8)
BYs, ksi (MPa)	209.7	(1446.1)	142.8 (984.3)	120.6	(832.4)
e/D = 2.0					
BUS, ksi (MPa)	262.0	(1806.0)	195.4 (1347.6)	192.6	(1328.3)
BYs, ksi (MPa)	242.0	(1669.0)	173.5 (1196.1)	140.7	(970.3)
<u>Fracture Toughness</u>					
K <sub>IC</sub> , ksi <sup>1/2</sup> in. (MPa·m) <sup>1/2</sup>	36.7 <sup>(b)</sup>	(40.4)	NA <sup>(c)</sup>	NA	
<u>Axial Fatigue</u>					
Unnotched, R = 0.1					
10 <sup>3</sup> cycles, ksi (MPa)	124	(854)	NA	73	(503)
10 <sup>5</sup> cycles, ksi (MPa)	64 <sup>(d)</sup>	(441)		48 <sup>(d)</sup>	(331)
10 <sup>7</sup> cycles, ksi (MPa)	45	(310)		35 <sup>(d)</sup>	(241)
Notched, K <sub>t</sub> = 3.0, R = 0.1					
10 <sup>3</sup> cycles, ksi (MPa)	(e)		NA	62 <sup>(d)</sup>	(427)
10 <sup>5</sup> cycles, ksi (MPa)	34	(234)		25	(172)
10 <sup>7</sup> cycles, ksi (MPa)	19	(131)		15	(103)

Ti-6Al-4V (Continued)

Properties	RT	Temperature, F (K)			
		(RT)	400	(477)	800
<u>Creep</u>					
0.2% plastic deformation, 100 hr, ksi (MPa)	NA	NA		47.5	(327.5)
0.2% plastic deformation, 1000 1000 hr, ksi (MPa)	NA	NA		34.0	(234.4)
<u>Stress Rupture</u>					
Rupture, 100 hr, ksi (MPa)	NA	NA		50.0	(344.7)
Rupture, 1000 hr, ksi (MPa)	NA	NA		42.1	(290.3)
<u>Stress Corrosion<sup>(f)</sup></u>					
$K_{ISCC} = 15 \text{ ksi}\sqrt{\text{in.}} \text{ (16.5 MPa}\cdot\text{m}^{1/2}\text{)}$					
<u>Coefficient of Thermal Expansion</u>					
$6.0 \times 10^{-6} \text{ in./in./F (70 - 800 F)}$ [ $10.8 \times 10^{-6} \text{ m/(m}\cdot\text{k)}$ (295 - 700 K)]					
<u>Density</u>					
0.159 lb./in. <sup>3</sup> (4.41 g/cm <sup>3</sup> )					

(a) Cold isostatically pressed, vacuum sintered and hot isostatically pressed. Values are average of triplicate tests conducted at Battelle under the subject contract unless otherwise indicated. Fatigue, creep, and stress-rupture values are from curves generated using the results of a greater number of tests.

(b)  $K_{IC}$  is valid as per ASTM E399.

(c) NA, not applicable.

(d) Estimated.

(e) Insufficient tests to estimate.

(f) This value is an approximate determination of  $K_{ISCC}$  at  $10^{-8}$  in./sec. ( $25.4 \times 10^{-8}$  mm/sec.). The increasing  $K$  tests lasted an average of 3 days and were conducted at 75 F (297 K) in 3-1/2% NaCl. Compact-tension-type specimens were used.

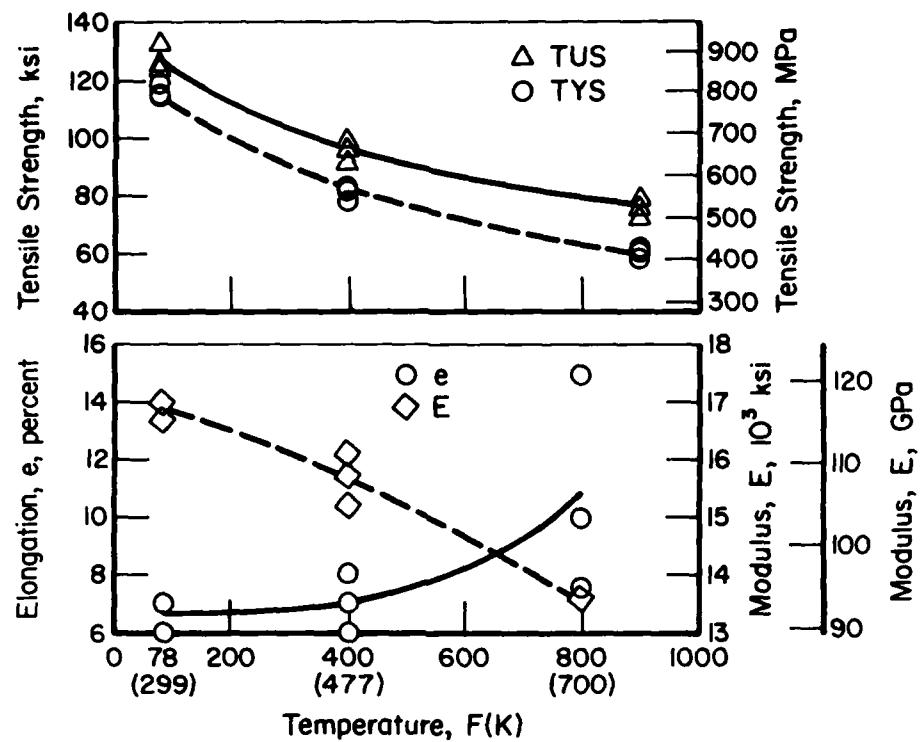


Figure 1. Effect of temperature on the tensile properties of Ti-6Al-4V (CHIP) Alloy.

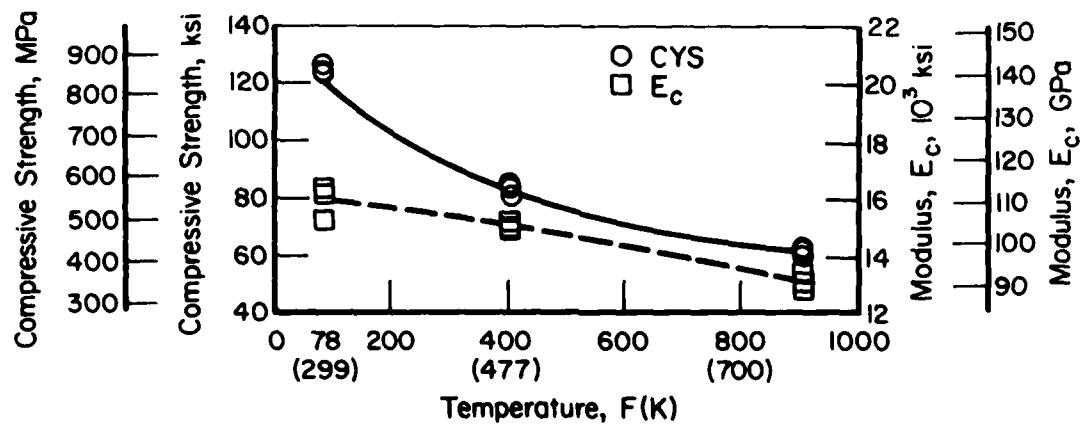


Figure 2. Effect of temperature on the compressive properties of Ti-6Al-4V (CHIP) Alloy.

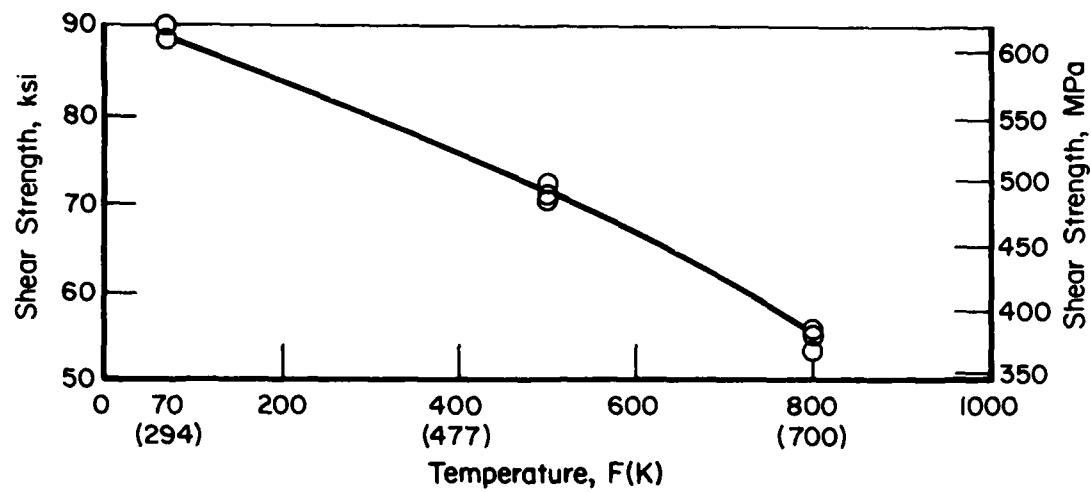


Figure 3. Effect of temperature on the pin shear properties of Ti-6Al-4V (CHIP) Alloy.

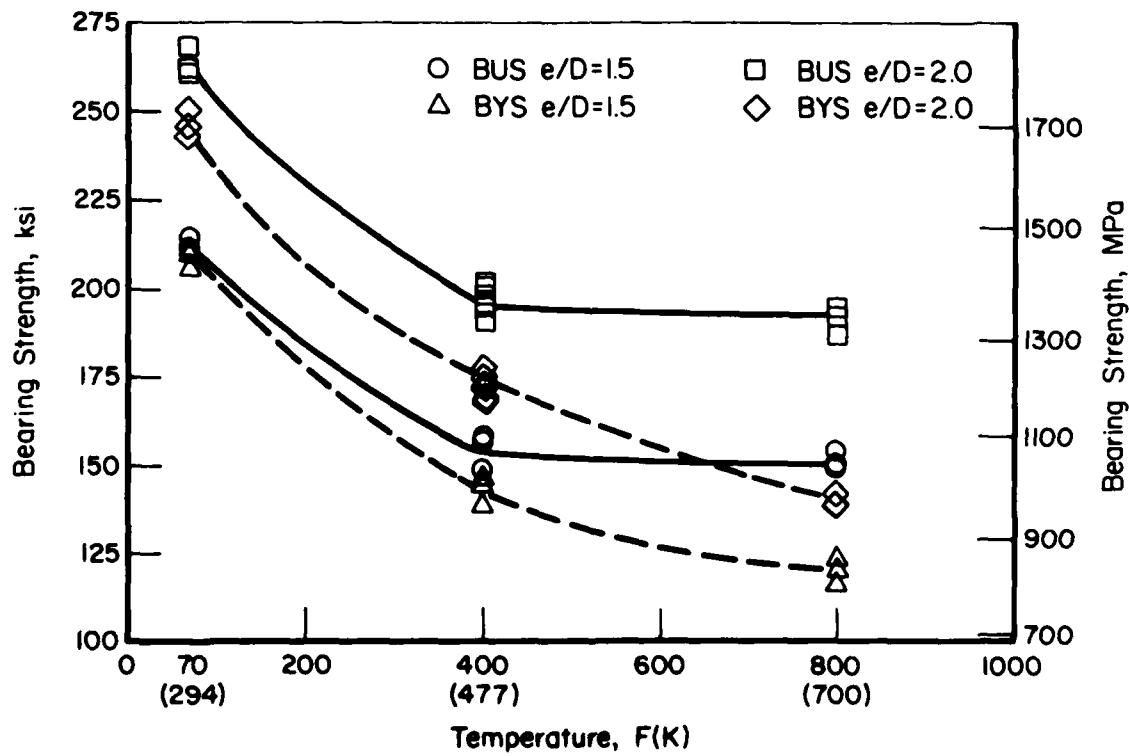


Figure 4. Effect of temperature on the bearing properties of Ti-6Al-4V (CHIP) Alloy.

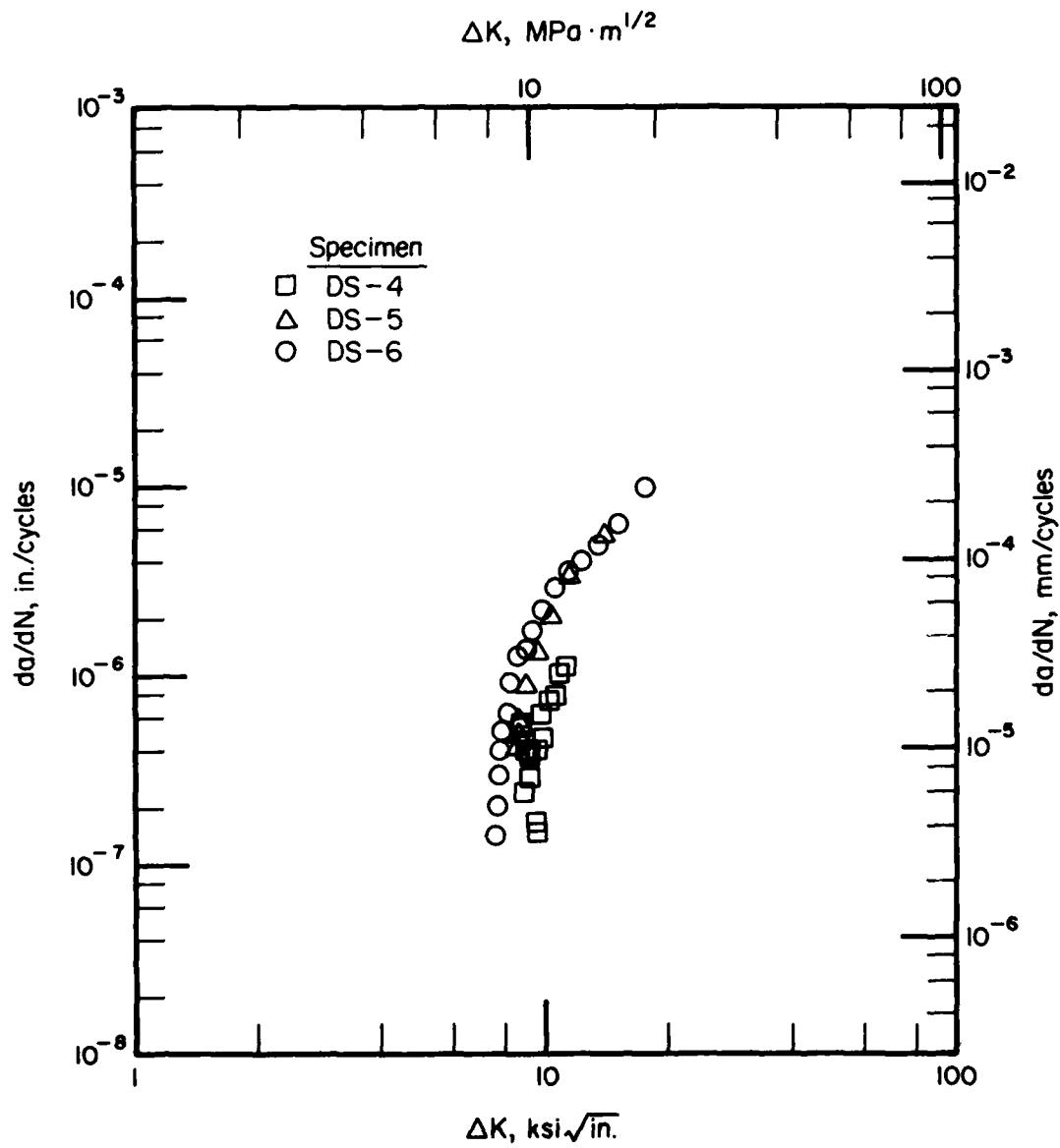


Figure 5.  $da/dN$  versus  $\Delta K$  for Ti-6Al-4V (CHIP) Alloy.

Lab Air  
 $R = 0.1$   
 Frequency = 20 Hz

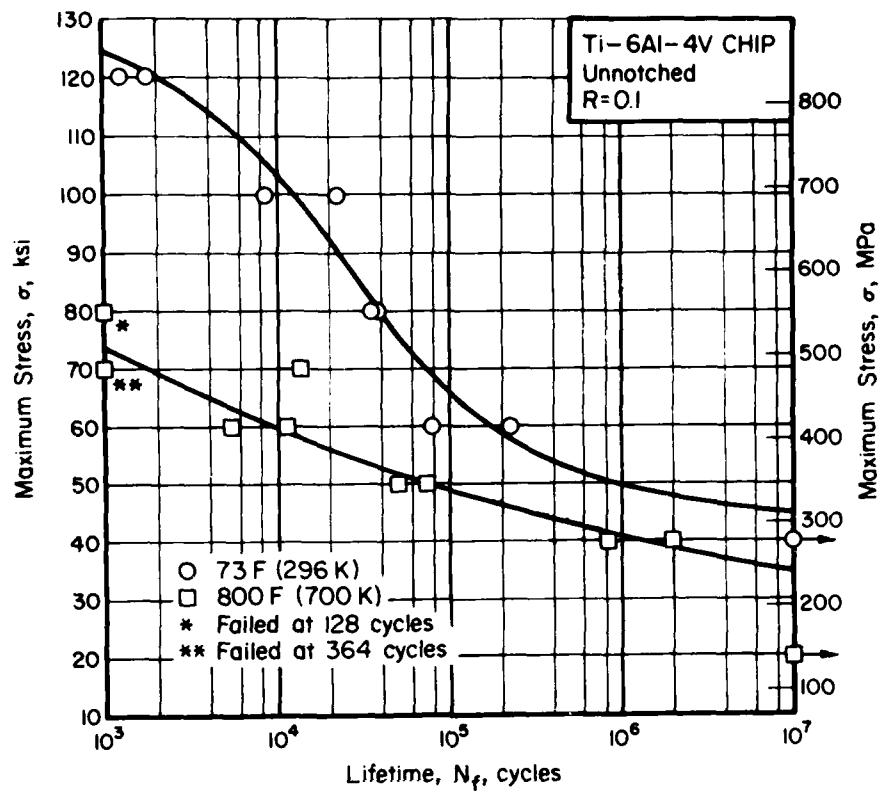


Figure 6. Axial load fatigue behavior of unnotched Ti-6Al-4V (CHIP) Alloy.

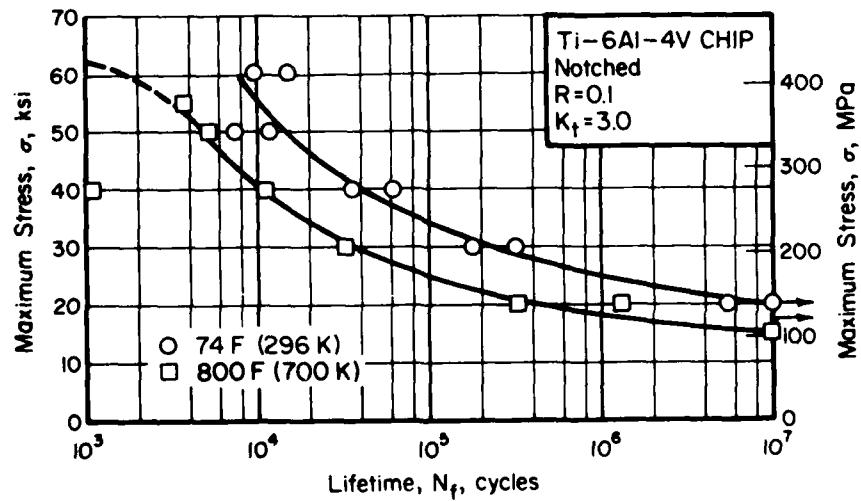


Figure 7. Axial load fatigue behavior of notched ( $k_t = 3.0$ ) Ti-6Al-4V (CHIP) Alloy.

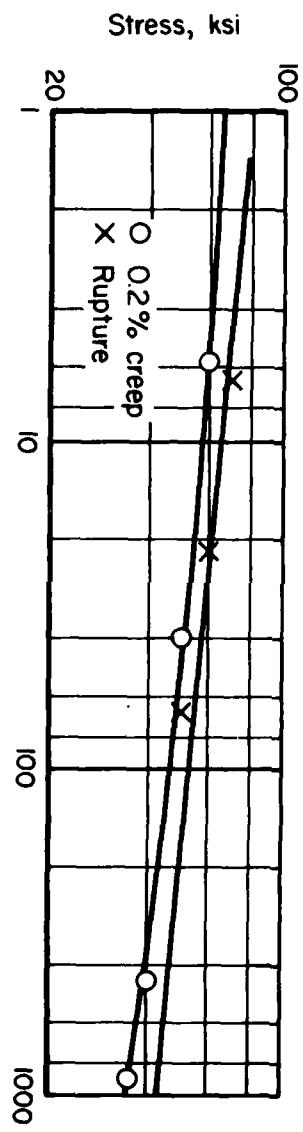


Figure 8. Stress-rupture and plastic deformation curves for Ti-6Al-4V (CHIP) Alloy.

